ESS

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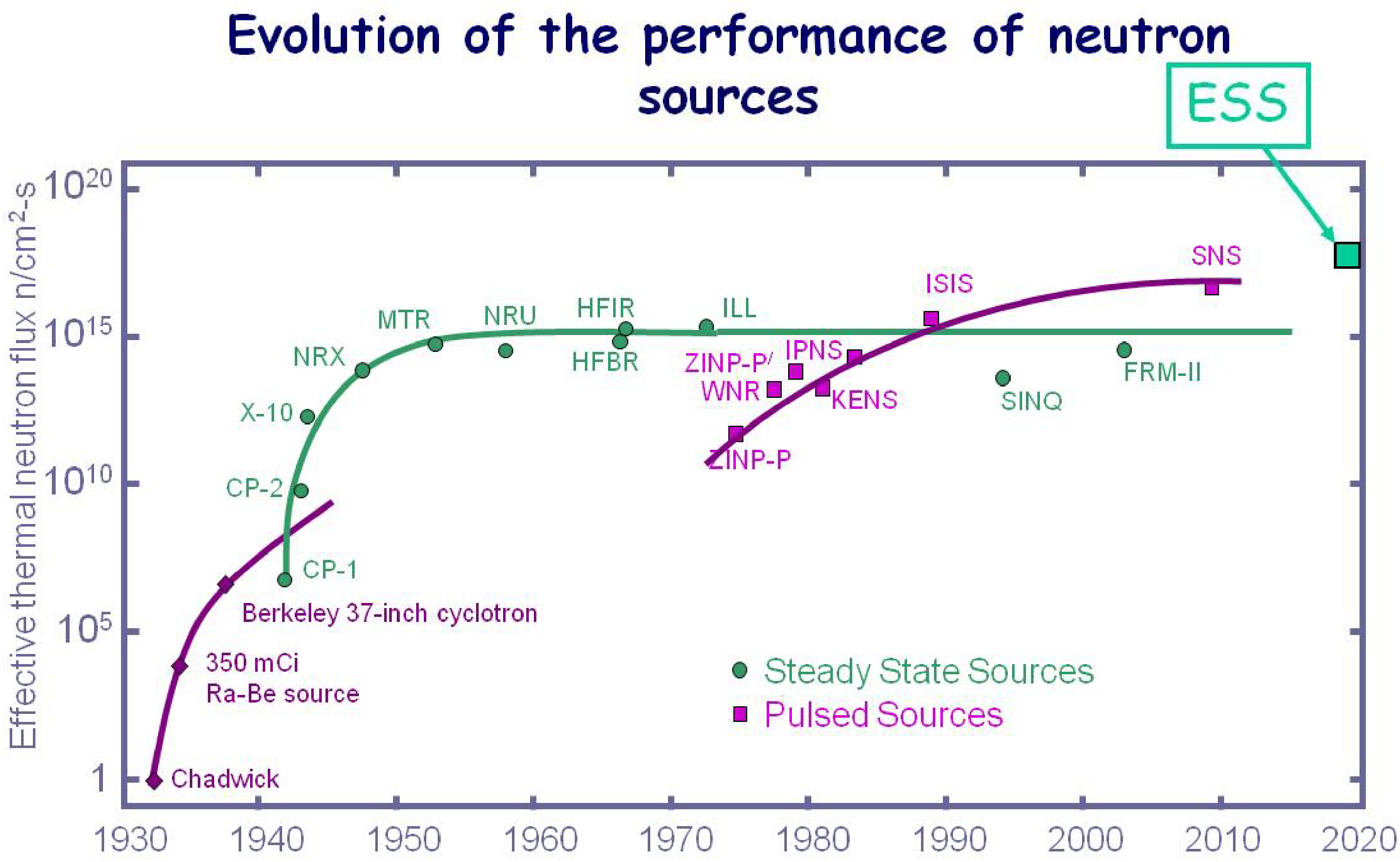
ESS



(Updated from *Neutron Scattering*, K. Skold and D. L. Price, eds., Academic Press, 1986)

European Spallation Source

SRF09

OECD “A High Power Spallation Source in each Global Region”

ESS: Site selection process

- ESS high up on the ESFRI list
  - Three consortia bidding for the site (Bilbao, Lund and Debrecen)
  - Evaluation by ESFRI in 2008 by site review group
  - Agreement on process to reach a site decision within the fringes of the European competitiveness council
  - Core group for ESS formed (14 countries) and decision on site at a Ministerial meeting in Brussels (28 May)
    - Lund proposed as ESS site with important contributions and supporting infrastructure in Spain
  - Integration of ESSB and ESSS accelerator and target teams
  - First Steering Committee meeting in Copenhagen 22-23 October 2009

ESS facility technical objectives:

5 MW (upgrade 7.5 MW) long pulse source

≤2 ms pulses

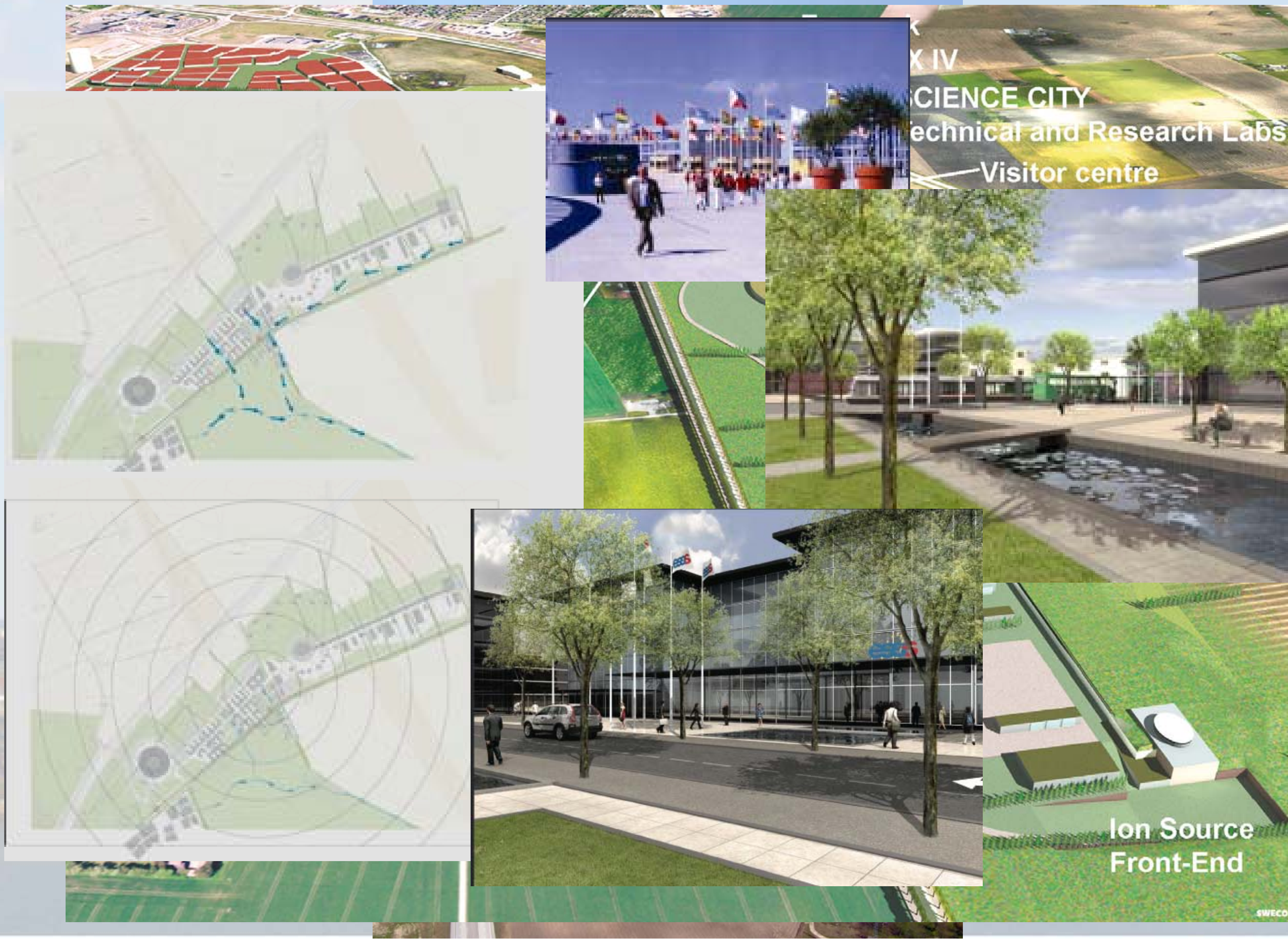
≤20 Hz

Protons (H+)

Low losses

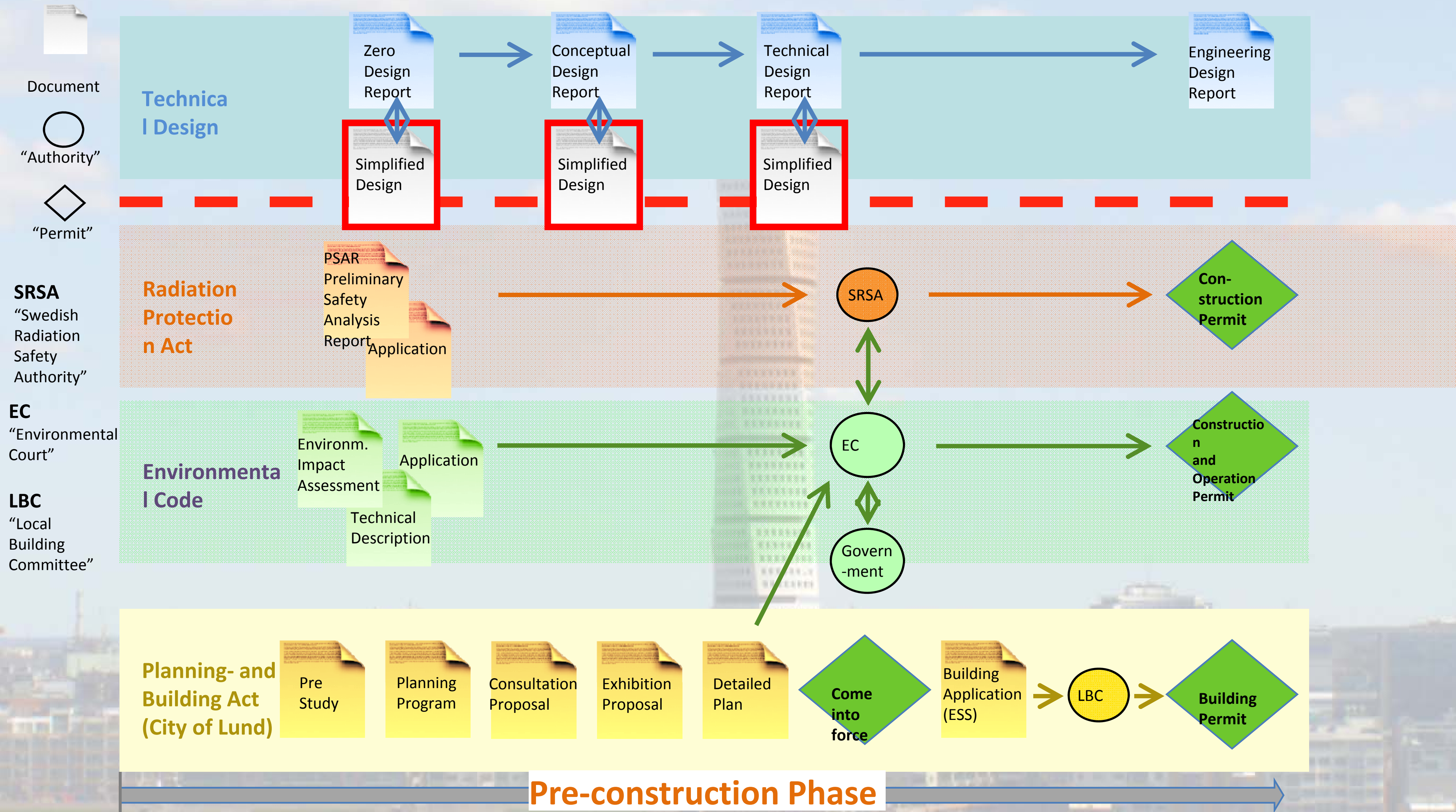
High reliability, >95%

Planning in progress

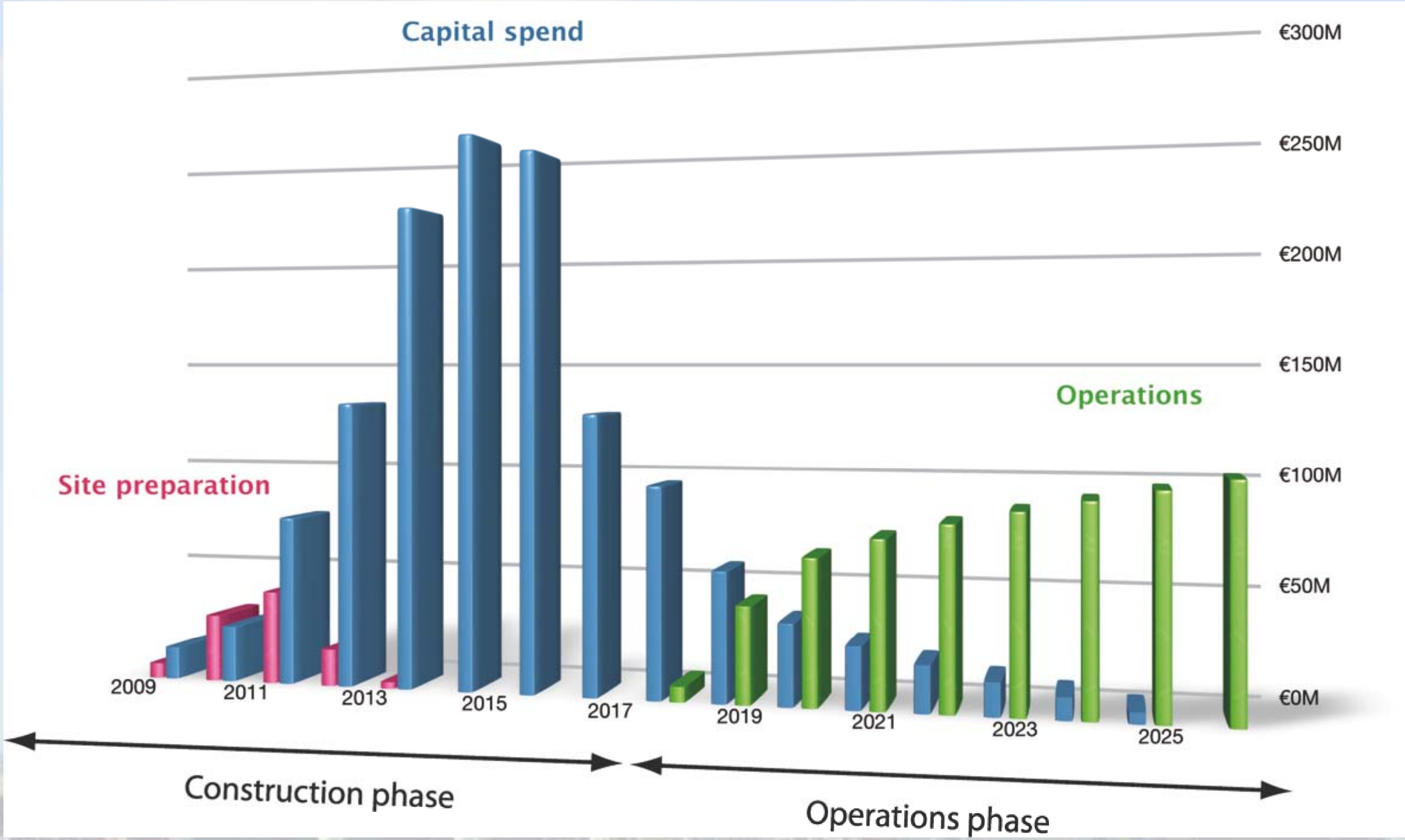


Licensing

GMY/2009-09-13

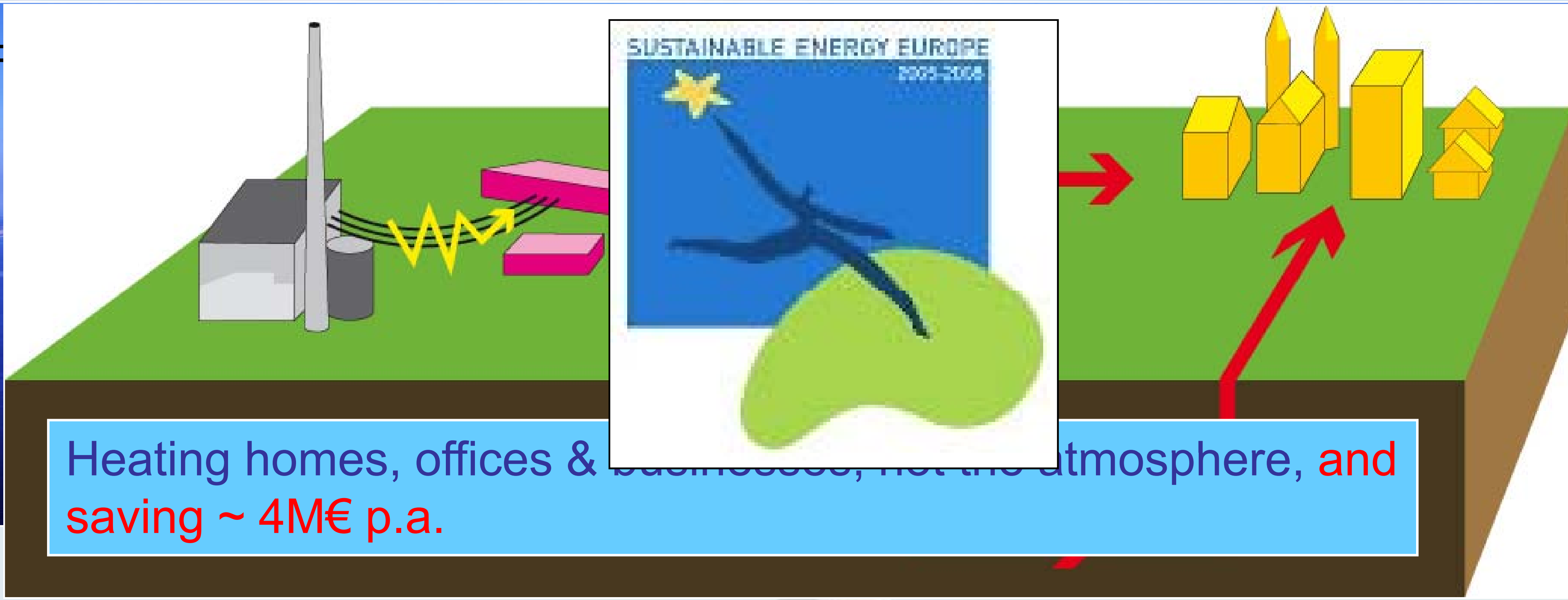


Budget



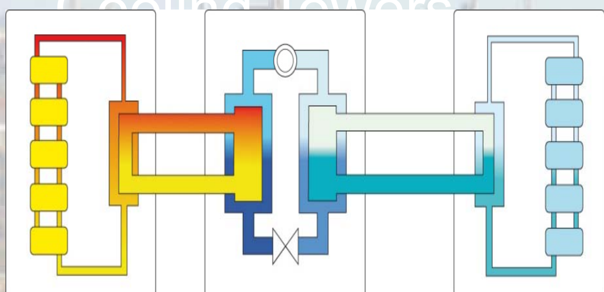
Facility investment: 1.377 M€$_{2008}$ with 22 instruments
+ 101 M€$_{2008}$ site specific cost
Operational cost: 89 M€$_{2008}$ per year
Decommissioning cost: 344 M€$_{2008}$

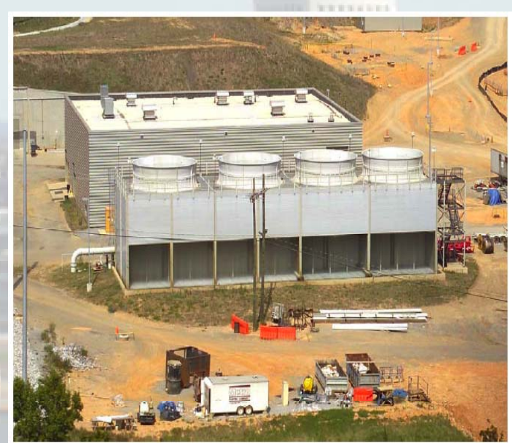
ESS: Climate neutral. Renewable energy and integration with the Lund District Heating & Cooling System (ref. Thomas Parker)

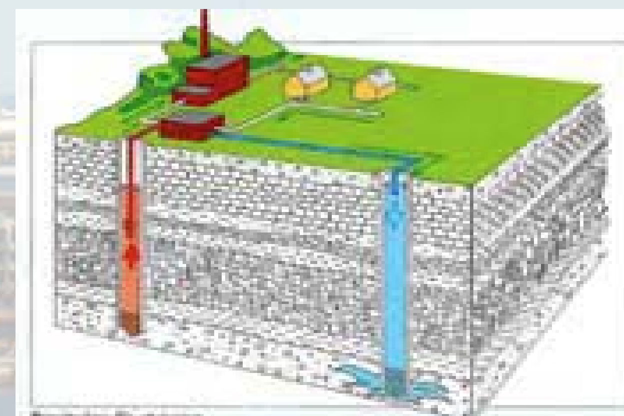


Heating homes, offices & businesses, not the atmosphere, and saving ~ 4M€ p.a.

Heat Exchangers not Cooling Towers

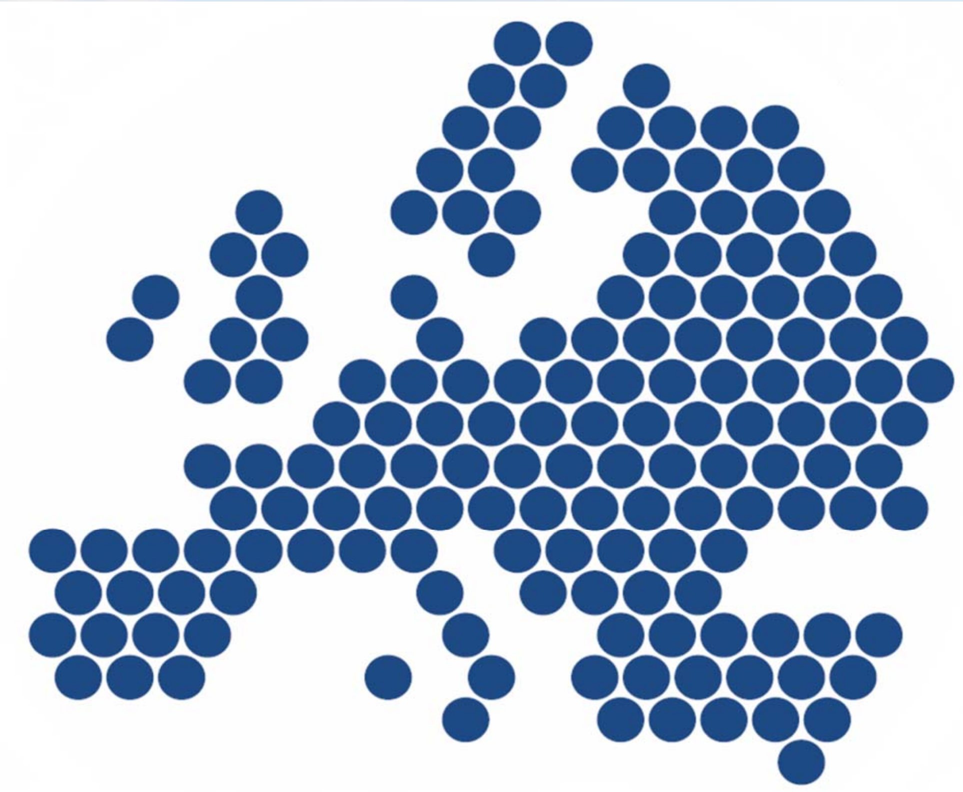






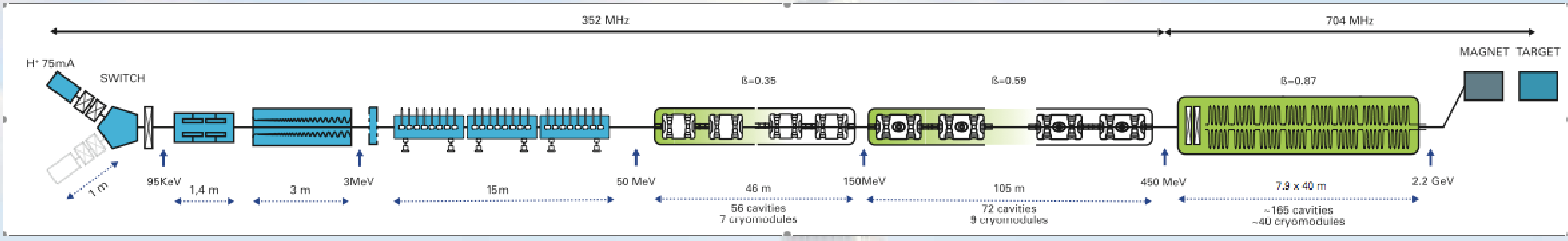
Design update: ESSB Preparatory work

ESS-Bilbao WORKSHOP PARTICIPANTS



*The workshop brought together more than **160 experts** from across the world, leaders in the fields of **high power proton accelerators**, **beam dynamics and targets**, in a format and infrastructure that promoted open discussion,*
*while maintaining the focus of documenting clear **recommendations** for **future collaborative R&D efforts**.*

ESS-Bilbao WORKSHOP ACCELERATOR COMPONENTS



*In comparison to the originally proposed design (5 MW, 1 GeV, 150 mA, 16.7 Hz) the parameters have been modified in order to **simplify the linac design** and to **increase reliability**. In essence the current has been decreased and the final energy has been increased, keeping the footprint of the accelerator the same.*

- ✓ ***Increase in energy*** *– With increased energy the average pulse current can be reduced by the same factor.*
- ✓ ***Increase of the cavity gradient*** *– By decreasing the current to 75 mA, the gradient can be raised to 15 MV/m, keeping the coupler power constant at 1.2 MW.*
- ✓ ***Increase of beam energy*** *- the final energy was increased from 1 to 2.2 GeV.*
- ✓ ***Repetition rate*** *- The originally proposed repetition rate of 16.67 Hz has been increased to 20 Hz.*
- ✓ ***Pulse length*** *- The originally proposed pulse length of 2 ms has been reduced to 1.5 ms*

Design update: ESSS Preparatory work

- Work with expert group (the ESSS linac reference group)

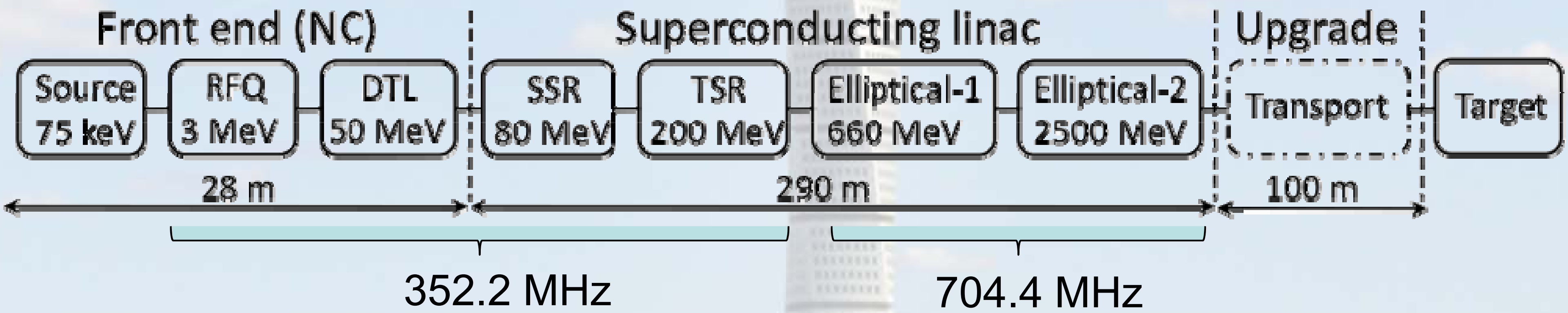
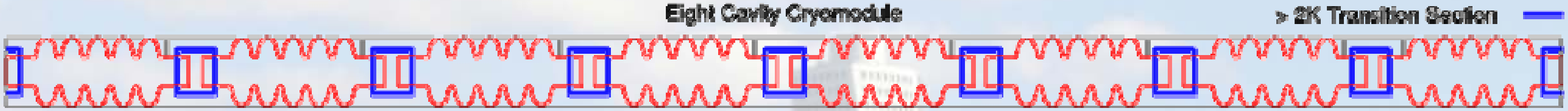


Table 1: Primary ESSS performance parameters in the long pulse conceptual design. There is no accumulator ring.

INPUT		Nominal	Upgrade
Average beam power	[MW]	5.0	7.5
Macro-pulse length	[ms]	2.0	2.0
Pulse repetition rate	[Hz]	20	20
Proton kinetic energy	[GeV]	2.5	2.5
Peak coupler power	[MW]	1.0	1.0
Beam loss rate	[W/m]	< 1.0	< 1.0
OUTPUT			
Duty factor		0.04	0.04
Ave. pulse current	[mA]	50	75
Ion source current	[mA]	60	90
Total linac length	[m]	418	418



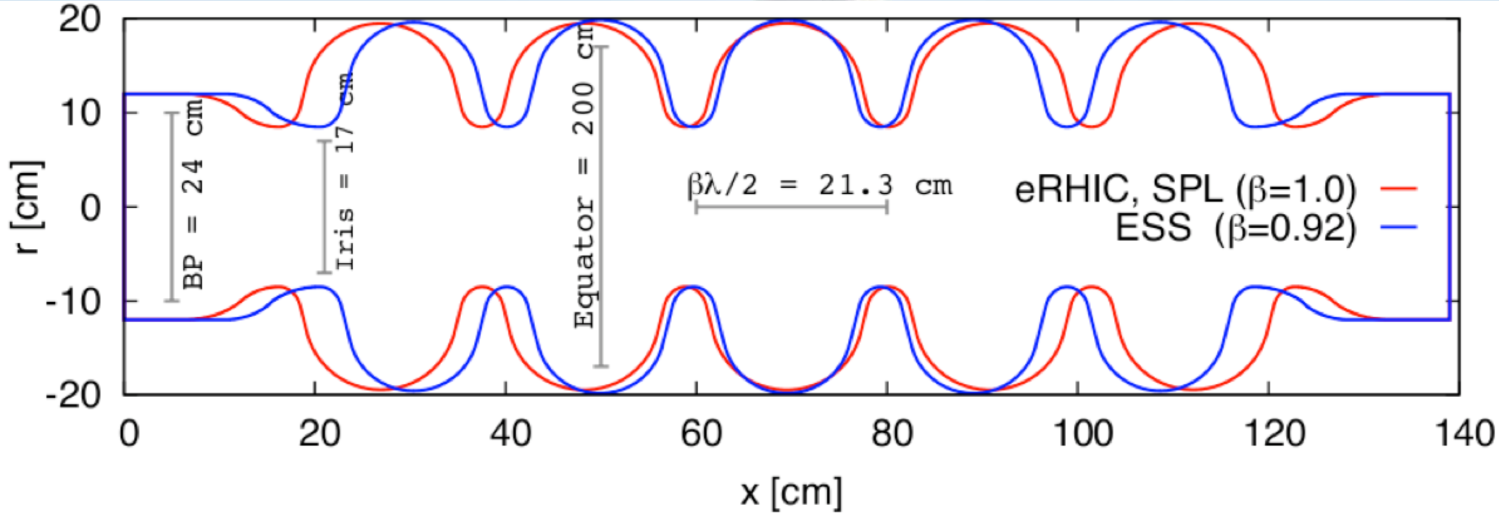


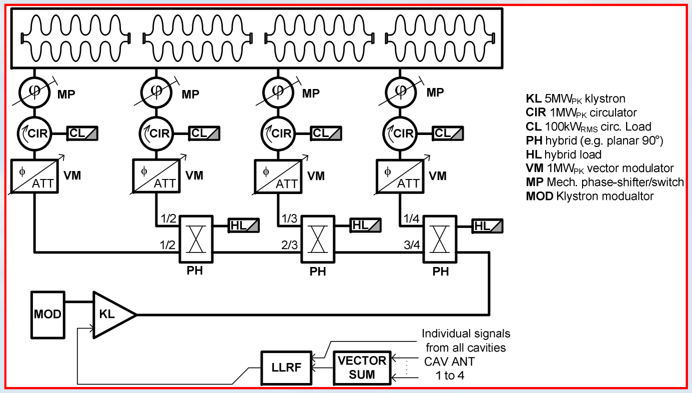
Figure 2: The five-cell 704 MHz cavity, showing the similarities between ESS, SPL and eRHIC structures.

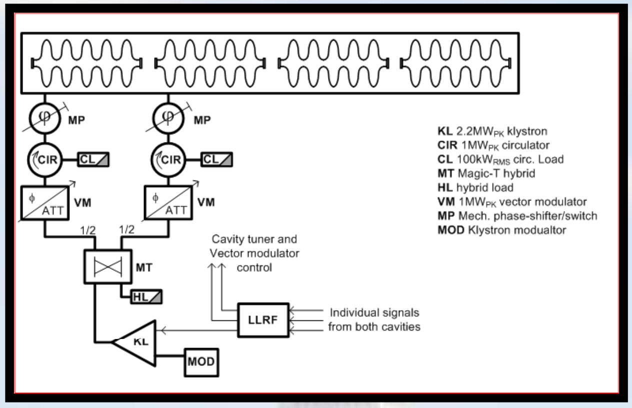
Many cavities

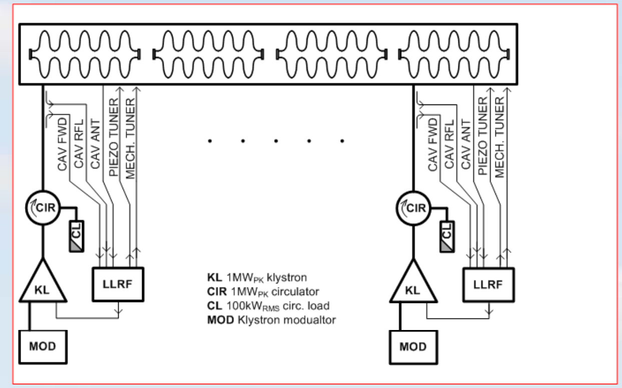
Structure	Number of Tanks or Cavities	Tank or Period Length	Frequency
RFQ	1	~4	352.21
DTL	3	~4	352.21
Single Spokes	24	3.9 (4 cavity, FODO)	352.21
Triple Spoke	32	6.1 (4 cavity, FODO)	352.21
Elliptical (0.65)	40 (SPL : 42)	6.2 (4 cavity, Doublet)	704.4
Elliptical (0.92)	96 (SPL : 200)	12.8 (8 cavity, Doublet)	704.4

- Approx. 200 cavities
  - RF distribution is a major part of budget!
- High availability requirements
  - Must be able to run linac even if some cavities are not operational
  - No complex solutions (dual couplers?)

RF distribution







Option	Configuration	Cost of 4 cavity (K-Euro)	For	Against
1	Four cavities per Klystron	2420	Fewest power sources	Complexity, bulk, power overhead, fault tolerence
2	One Cavity per Klystron	2880	Reduced hardware inventory, minimum R&D, fully independent control, minimum RF power overhead, best fault tolerance, easy upgrade to HPSPL	Number of power sources
2a	One cavity per IOT	2520	As above, perhaps cheaper & more compact	HPSPL would need doubling of IOTs, or larger rating IOTs
3	Two cavities per Klystron	2520	Half the number of klystrons	Need full hardware set, associated R&D, Power overhead, Reduced flexibility wrt option 2
3-VM	Two cavities per Klystron Without VMs	2370	Half the number of klystrons, more economical than Option 3	Risk for higher intensity?

Design update: Some issues

Question for future users and ESS technical teams:

- How long is the ideal "long pulse" and what is the ideal repetition rate? (0.75-2 ms, 10-20 Hz)
- Can the neutron pulse be shaped in a more useful shape for physics through shaping of the proton pulse?
- Can we confirm that the neutron intensity at the instruments is constant per MW up to a certain energy? (< 3 GeV)
- What flexibility can be left in the design for future upgrades without compromising construction time, schedule and budget?
- Using the best SCRF technology, what is the optimum design of the linac with given objectives?

Collaboration model for linac design!

Work Package (work areas)

1. Management Coordination
2. Beam Physics
3. Infrastructure Services
4. SCRF Spoke cavities
5. SCRF Elliptical cavities
6. Front End and NC linac
7. Beam transport, NC magnets and Power Supplies
8. RF Systems

Collaboration model: Required

- A collaboration to share interesting R&D, assure an all European effort and kick start the ESS work
- A strong Coordination Team in Lund to take the intellectual ownership of the design, to follow the work, to assure good project cost control, and to be responsible for project integration
- A collaboration board to assure good coordination and to address poor performance
- Use of common standards, web based documentation, regular reporting and appropriate costing tools
- Regular reviews of critical path deliverables and even milestones of large work packages (if at a single institute)

EURISOL T8 Design Study

Synergies for linac

INFN Istituto Nazionale di Fisica Nucleare

Half-wave resonators

- Two prototypes @ 352 MHz (β 0.17 and β 0.31) fabricated and tested

IPN Orsay Division Accélérateurs

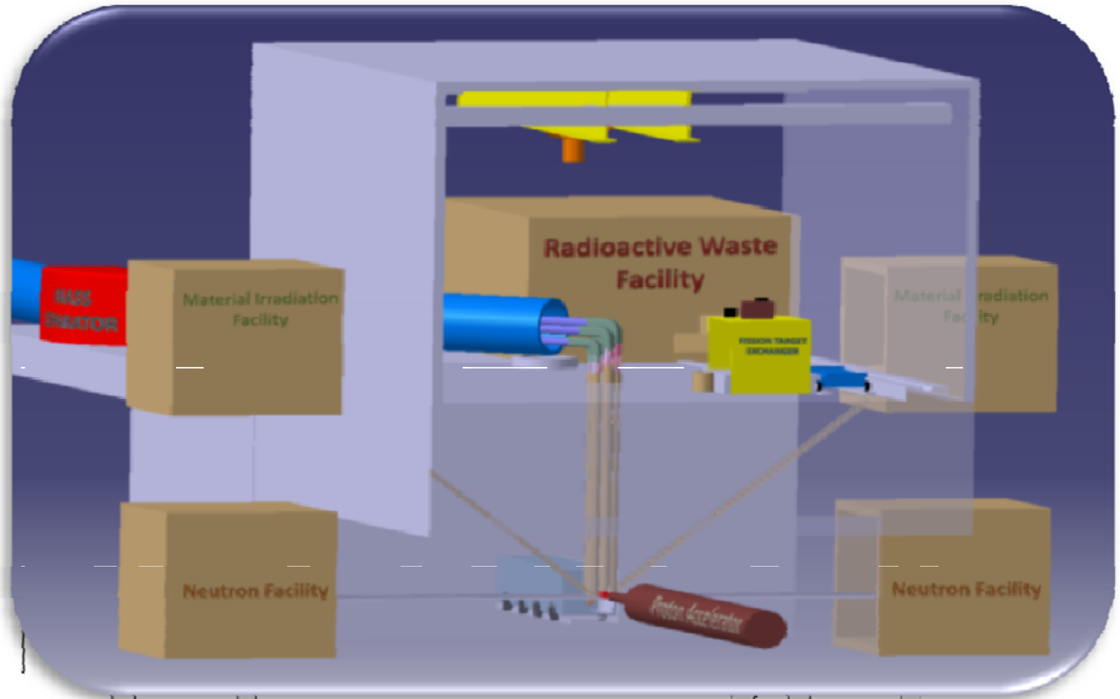
Spoke resonators

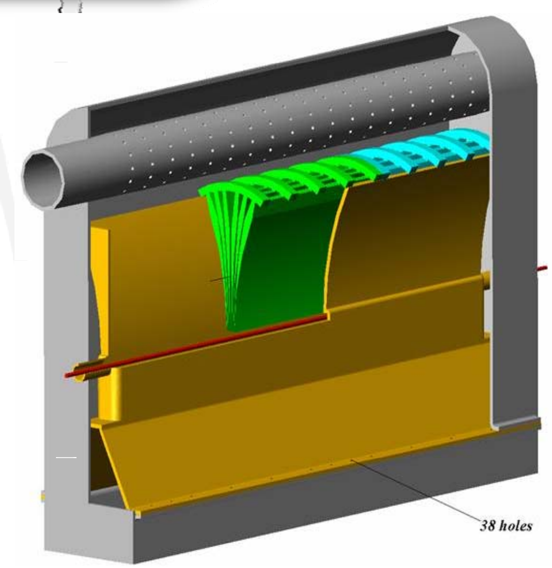
- Two prototypes @ 352 MHz (β 0.15 and β 0.35) fabricated and tested.

ALL SUCCESFULLY TESTED !

Synergies for target

EURISOL
Design Study





ABOVE: The EURISOL conceptual multi MW fission target design approved by International Review Panel

RIGHT: New type of window less liquid curtain neutron converter proposed

SPL construction, stage 2:

LP-SPL (4 GeV)

- construction of Low-Power SPL together with PS2,
- main users: PS2 (LHC), ISOLDE upgrade, EURISOL-0 (?),
- operation in 2020

kinetic energy	4 GeV
beam power (@ 4 GeV)	0.14 MW
repetition rate	0.6 - 2 Hz
pulse length	0.9 ms
average pulse current	20 mA
protons p. pulse	$1.1\ 10^{14}$
length (SC linac)	427 m

Conclusions

- ESSS and ESSB has become ESS which now has 12 future member states
  - Site for facility in Lund in Sweden
- First neutrons for 2019 with full design specifications in 2023
  - Ambitious goals requires ambitious planning
- Build on latest SC RF R&D
  - Requires high reliability and low losses
- Maximize synergies with other similar projects
  - Cost and time gains
  - Trained people are in short supply
- Very challenging task…
  - That is our job…
  - …and that is why we are here!

Linac subsystems

Table 2: Primary linac sub-system parameters.

System	T [K]	Energy [MeV]	Freq. [MHz]	β Geom.	Length [m]
Source	300	0.075	–	–	2.5
LEBT	300	–	–	–	1.1
RFQ	300	3	352.2	–	4.0
MEBT	300	–	352.2	–	1.1
DTL	300	50	352.2	–	19.2
SSR	4	80	352.2	0.35	23.3
TSR	4	200	352.2	0.50	48.8
Ellipt-1	2	660	704.4	0.65	61.7
Ellipt-2	2	2500	704.4	0.92	154.0